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ANNOTATION AND CONTROL SUBROUTINE SUBPROGRAMS FOR INTERACTIVE G--ETC(U)

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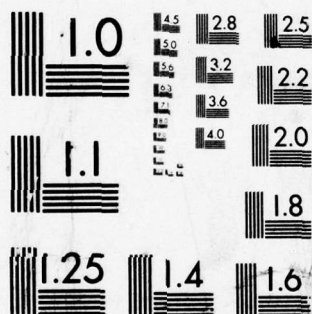
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TECHNICAL REPORT RG-77-1

**ANNOTATION AND CONTROL SUBROUTINE
SUBPROGRAMS FOR INTERACTIVE
GRAPHIC DISPLAYS**

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5 November 1976

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Recently, numerous digital computer simulation programs have been developed and/or modified to incorporate the usage of the interactive computer graphics terminal system into their resulting output. The interactive computer graphics terminal system is used primarily to obtain interactive graphic displays as a portion of the simulation program output results. These displays are ideal for data analysis, data reduction and retention, and for			

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ABSTRACT (Concluded)

inclusion within presentations and technical reports. However, these displays require annotations such that they can be identified at some future date. Certain difficult problems are associated with these annotations and their placement on the interactive graphic displays. Hence, this technical report is an attempt to describe those difficult problems, to provide a technique for their solution, and to acquaint the interactive computer graphics terminal system user of their existence. The use of these techniques and subroutines should make the interactive computer graphic displays more easily annotated and controlled than they have been in the past.



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I. INTRODUCTION

Digital computer simulation programs are continuously being developed, or simplified in some manner, to incorporate the interactive computer graphics terminal system to obtain graphic displays as a portion of their output results. These displays are ideal for data analysis, reduction and retention purposes, as well as for inclusion within technical reports and presentations. However, the displays require annotations and labelings such that they can be identified at some future date for reference purposes. Certain difficult problem areas are encountered with the annotations and their placement on the interactive graphic displays.

This technical report, therefore, fully documents for the interactive computer graphics terminal system user some of the more difficult problem areas, techniques and methods for their solution, and available subroutines which have been developed for interactive graphic display annotations and control. A discussion of the difficult problems of graphic display annotations is contained in Section II of this technical report. Section III presents a possible technique and method for the solutions to the problems. Subroutine subprograms, which have been developed and placed in the system library, for graphic display annotations and control are completely documented in Section IV along with examples of their usage. Section V contains an application program which illustrates the utilization of the graphic display annotation and control subroutines. The results, conclusions, and recommendations for future study and application are contained in Section VI.

These simulation programs and subroutine subprograms are presently being used on the interactive computer graphics terminal system [1,2] located in the Guidance and Control Analysis Simulation Facility of the US Army Missile Command's Guidance and Control Directorate at Redstone Arsenal, Alabama. This simulation facility is described by Jolly et al. [2]. Familiarity with digital computer system operations and some knowledge of computer programming languages, in particular, Fortran IV [3-10], has been assumed.

II. STATEMENT OF THE PROBLEM

This section contains a discussion of some of the more difficult problems associated with the annotating and controlling of the graphic display plots by the interactive computer graphics terminal system. First of all, the input/output (I/O) done by the terminal control system (TCS) Plot-10 software is performed by two subroutines, RD7611 for input and WT7611 for output, respectively. A description of the TCS Plot-10 software is presented in reports by Tektronix, Inc. [11,12]. Alternate entry points for the two subroutines are TINPUT and TOUTPT for input and output, respectively. These routines are system-dependent and must be provided for each digital computer system.

Their function is simply to input and output American Standard Code for Information Interchange (ASCII) characters (see the ASCII Table in Appendix A). The data are transferred to and from the Xerox Sigma 5 analog coupler driver system and the Tektronix model 4002A graphics computer terminal by the Xerox model 7611 character-oriented communications (COC) controller on a character-by-character basis; for output, the character is contained in the rightmost byte of the word (i.e., byte 3).

Secondly, the Extended Binary-Coded-Decimal Interchange Code (EBCDIC) is used by the Xerox Sigma 5 analog coupler driver simulation facility, where there are four characters or bytes per word. Therefore, this presents a problem of conversion from EBCDIC to ASCII for graphic display output and from ASCII to EBCDIC for input. Additionally, only certain characters may be converted from EBCDIC to ASCII and vice-versa by the subroutines and function subprograms provided in the COC I/O, control, and utility software package. The particulars pertaining to the character code conversion processes can be found in Appendix A.

Finally, the characteristics of, and strappable options available and provided with, the Tektronix 4002A graphic computer terminal effect the annotations and control of the graphic display output. Some of the more important characteristics and options are as follows:

- a) 39 lines of 85 normal size or italic characters in the main display area. One line of 84 characters in the scratch pad area.
- b) A 94 upper and lower case printing character (ASCII code) set.
- c) The optional character rotator card module, which is installed in the drawer unit of the Tektronix 4002A, provides for the rotation of displayed characters in increments of 90 deg in a clockwise direction.
- d) The optional horizontal tab feature permits insertion and removal of horizontal tab positions and shifting the start of the displayed line to any selected tab position.

These characteristics and options have the following affects upon the graphic displays:

- a) If a line of output characters greater than the 85 allowed is attempted, the output is jumbled on the right side of the cathode ray tube (CRT) display screen area.
- b) If more than the 39 allowed number of lines is attempted, the output is returned to the "home" position (top left of the screen) and the output is continued until completion. This causes overlapping and overprinting of output on the display area.

Appendix B presents a standard operating procedure for "turning-on" the Tektronix 4002A graphic computer terminal each morning. This procedure should help in eliminating the difficulty usually encountered in obtaining the first graphical displays from a digital computer program when the Tektronix 4002A terminal is first "powered-up."

III. SOLUTION OF THE PROBLEM

The obvious solution to the difficult problem areas is to develop generalized subroutine subprograms for handling the annotations and control of graphic displays. These generalized subroutines have been developed and placed in the system library of the Xerox Sigma 5 analog coupler driver simulation system facility. If any of the subroutines are required by a user's application program, the subroutines are loaded at load time by the overlay loader "OLOAD" processor of the hybrid real-time batch monitor (HRBM) operating system. These subroutines have been written in the extended Fortran IV programming language; however, the subroutines are compatible for usage with application programs written in the Fortran IV-H programming language and/or with the macro-symbol assembler language, provided the proper linkage is established. Thus, the subroutines are easily accessed by all application users of the interactive computer graphics terminal system.

The objective of this report is to describe the function and usage of these graphic display annotation and control subroutines. The functional description and examples for usage of the annotation and control subroutines for graphic displays are contained in Section IV. Section V presents a typical application program for the interactive computer graphics terminal system which makes use of the graphic display annotation and control subroutines.

For comparison purposes only, Appendix C includes four programming examples which illustrates the various methods and techniques of annotating and controlling the interactive graphic display plots.

IV. THE SUBROUTINE SUBPROGRAMS

A. Subroutine CHARRD

This subroutine enables a user to interactively control the generation and hard copy output of CRT displays. Control is provided by characters input via the Tektronix 4002A keyboard. These control characters enable a user to obtain a hard copy of a graphic display, to redraw the current display(s), or to step to the next program function. The control characters are upper case; i.e., the shift lock key of the CRT keyboard should be depressed prior to selecting a control character. The control characters and their functions are as follows:

- C - Continue to the next program function (Fortran statement, assumed) following the call to subroutine CHARRD.
- D - Produce a hard copy of the current display and wait for further control characters to be input.
- R - Return to the statement label specified in the calling sequence.

Calling Sequence:

where:

A normal return (to the statement following the call to CHARRD) is made when the C control character is detected.

BELL
HDCOPY
NDIG
NSTCK
RD7611

```

      .
      .
105 CONTINUE
      .
      .
      CALL CHARRD (&105)
      .
      .

```

```

1:      SUBROUTINE CHARRD(*)
2:      1203 CALL BE__
3:      1201 CALL RD7611(1, ICHAR, IFLAG)
4:      IF (IFLAG .EQ. 0) G9 T9 1201
5:      1202 IF (NSTACK(I) .GE. 4) G9 T9 1202
6:      ICHAR1 = NDIG(ICHAR, 1, -10)
7:      IF (ICHAR1 .EQ. 67) RETURN
8:      IF (ICHAR1 .EQ. 68) CALL HDSOPY
9:      IF (ICHAR1 .EQ. 82) RETURN 1
10:     G9 T9 1203
11:     END

```

6

Input:

The execution of control character selected for input from the Tektronix 4002A keyboard as subroutine CHARRD depends upon the expected output results. The possible inputs have already been described previously as: 'C' - to continue, 'D' - to make a hard copy, and 'R' - to transfer control to a Fortran statement label of the calling routine.

Output:

The output resulting from the execution of subroutine CHARRD is dependent upon the control character selected as input from the 4002A keyboard (see preceding input).

B. Subroutine HITLES

Subroutine HITLES enables a user to output specified character strings for graphic plot display annotations. The user must specify position and character orientation for the character strings, where position specifies the starting position for the first character of the string (specified in screen coordinates). Orientation specifies that the character strings shall be output either as a horizontal string read in a left to right manner, or a vertical string with each character rotated 90 deg counterclockwise such that the character string is read from bottom to top, i.e., assuming the bottom of the CRT display is the horizontal axis.

Calling Sequence:

CALL HITLES (LS,MH,MV,NC,HLAB)

where:

- LS - An integer variable with a value of 1 or 2. A value of 1 specifies that the character string is to be output horizontally and a value of 2 specifies that the character string shall be output vertically with the 90-deg counterclockwise rotation.
- MH - An integer variable that specifies the screen coordinates in the X-direction from the lower left corner of the CRT display for the first character of the string.
- MV - An integer variable that specifies the screen coordinates in the Y-direction from the lower left corner of the CRT display for the first character of the string.
- NC - An integer variable that specifies the number of characters in the character string to output.

HLAB - An array containing the EBCDIC character string to be output to the CRT graphic display. The calling program (main/subroutine) may generate this string by filling the array with Hollerith constants or by specifying a Literal constant.

External Subprograms Required:

HLABEL
MOVABS
NASCII
NSTCK
RVTITL

Example(s) of Usage:

Example No. 1. Depleting Hollerith constant data.

```
CALL HITLES(1,150,75,26,26H INDEPENDENT  
VARIABLE LABEL)  
CALL HITLES(2,60,640,24,24H DEPENDENT  
VARIABLE LABEL)
```

Example No. 2. Containing Hollerith and Literal constant data.

```
DIMENSION LABH(7),LABV(6)  
DATA LABH/'INDEPENDENT VARIABLE LABEL '/  
DATA LABV/24HDEPENDENT VARIABLE LABEL /  
CALL HITLES(1,150,75,26,LABH)  
CALL HITLES(2,60,640,24,LABV)
```

Example No. 3. With Literal constant data.

```
CALL HITLES(1,150,75,26,'INDEPENDENT VARIABLE LABEL')  
CALL HITLES(2,60,640,24,'DEPENDENT VARIABLE LABEL')
```

A listing of the subroutine HITLES is shown in Figure 2.

```

1:      SUBROUTINE HITLES(LS,MH,MV,NC,HLAB)
2:      INTEGER HLAB(NC)
3:      INTEGER HL(80)
4:      DO 20, I = 1,NC
5:      HL(I) = NASCII(HLAB,I)
6:      20 CONTINUE
7:      GO TO (30,40), LS
8:      30 CALL MBVABS(MH,MV)
9:      CALL HLABEL(NC,HL)
10:     GO TO 10
11:     40 CALL RVTITL(MH,MV,NC,HL)
12:     10 IF(NSTCK(I) .GE. 3) GO TO 10
13:     RETURN
14:     END

```

Figure 2. Listing of subroutine HITLES.

Output:

The output to the CRT display resulting from subroutine HITLES execution is dependent upon the parameters passed within its calling sequence. For the simple examples previously given, the output appearing on the CRT display screen is shown in Figure 3.* Other illustrations, which contain calls to subroutine HITLES and its resulting output, are shown in other subsections and in Section V of this report.

Input:

None, the parameters that are required of subroutine HITLES are passed within the calling statements.

C. Subroutine RVTITL

The subroutine RVTITL outputs to the CRT display character strings specified by ASCII integer values in the vertical manner with each character rotated 90 deg counterclockwise. Then, the character string is read from bottom to top. The user must specify the starting position for the first character of the string also, as well as the number of characters to be output.

*This figure was output from program example number 4 in Appendix C.

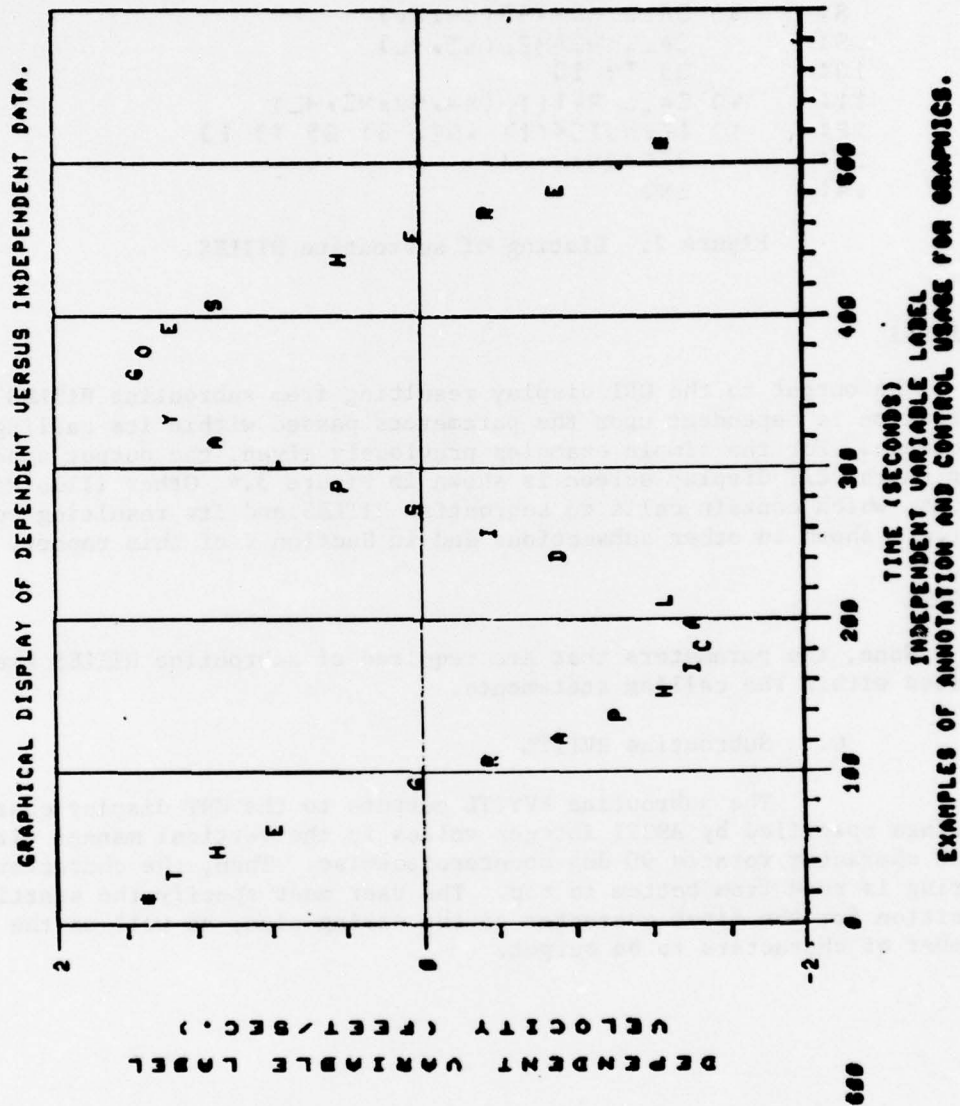


Figure 3. CRT display output by subroutine HITLES.

Calling Sequence:

CALL RVTITL(MH,MV,NC,LABRV)

where:

- MH - An integer variable that specifies the screen coordinate in the X-direction from the lower left corner of the CRT display for the last character of the string.
- MV - An integer variable that specifies the screen coordinate in the Y-direction from the lower left corner of the CRT display for the last character of the string.
- NC - An integer variable that specifies the number of characters in the character string to output.
- LABRV - An array containing the ASCII integer values of the character string to be output to the CRT display.

External Subprograms Required:

ANMODE
MOVABS
NSTCK
TOUTPT
WT7611

Example(s) of Usage:

```
      :  
      :  
      DIMENSION LABRV(26)  
      DATA LABRV/73,78,68,69,80,69,78,68,69,78,84,32,  
      186,65,82,73,65,66,76,69,32,76,65,66,69,76/  
      :  
      :  
      CALL RVTITL(MH1,MV1,NC1,LABRV(3))  
      CALL MOVABS(MH2,MV2)  
      CALL HLABEL(26,LABRV)  
      :  
      :
```

A listing of the subroutine RVTITL is shown in Figure 4.

```

1:      SUBROUTINE RVTITL(MH,MV,NC,RVLAB)
2:      INTEGER RVLAB
3:      DIMENSION RVLAB(NC)
4:      CALL MOVABS(MH,MV)
5:      CALL ANMODE
6:      CALL NT7611(21)
7:      CALL NT7611(21)
8:      CALL NT7611(21)
9:      DO 10 J = 1,NC
10:     < = (NC+1) - J
11:     CALL NT7611(RVLAB(<))
12:     CALL T9JTP(8)
13:     CALL T9JTP(10)
14:     20 IF(NSTCK(I) .GE. 3) GO TO 20
15:     10 CONTINUE
16:     CALL NT7611(21)
17:     RETURN
18:     END

```

Figure 4. Listing of subroutine RVTITL.

Input:

None, the parameters that are required of subroutine RVTITL are passed by the calling statement.

Output:

The output to the CRT graphic display area resulting from subroutine RVTITL execution is dependent upon the parameters contained within its calling statement. For the simple examples previously given, the output appearing on the CRT display area is shown as in Figure 5. Heretofore, it has been the customary practice to make the following statement calls:

```

:
:
CALL MOVABS(MH1,MV1)
CALL VLABEL(NC1,LABRV(3))
CALL MOVABS(60,600)
CALL VLABEL(20,IDVL)
:
:

```

to obtain the CRT display as shown in Figure 6 on the Tektronix 4002A graphic computer terminal screen.

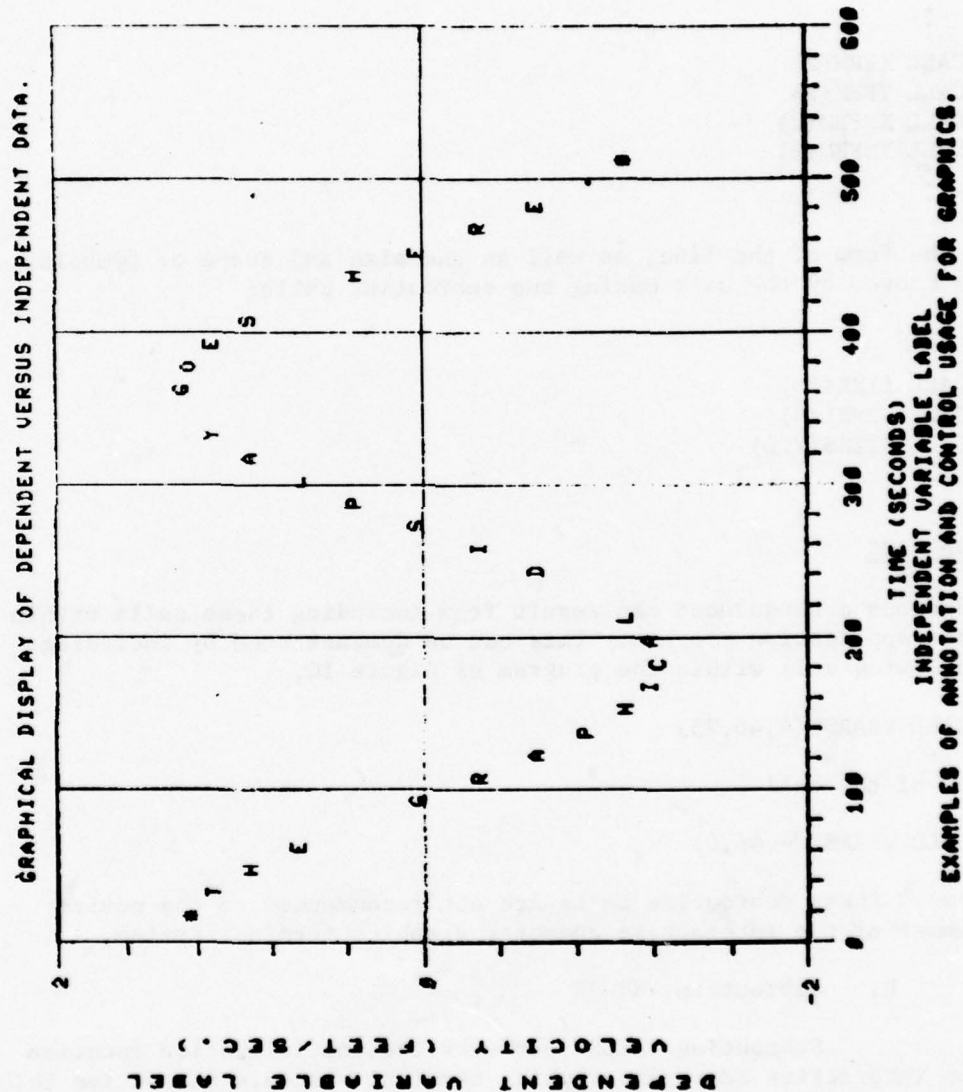


Figure 5. CRT display output by subroutine RVTITL.

Program example number 3 (Appendix C) was used in obtaining the output results contained in Figure 5. This is, in reality, Figure 3 redrawn to a different scale. Figure 6 is the output resulting from the execution of program example number 2 statements in Appendix C. Notice that this is the customary practice for obtaining the grid lines and tick marks on the graphical display plot. However, the user may control these options by including various calls to routines to handle these functions as described in References 11 and 12 and as shown in the program listings of Figure 10 and Figure C-2 in Appendix C. These subroutine calls include the following:

```

:
CALL XFRM(2)
CALL YFRM(2)
CALL XMFRM(2)
CALL YMFRM(2)
:

```

Also, the form of the line, as well as the size and shape of symbols, can be chosen by the user making the subroutine calls:

```

:
CALL LINE(14)
CALL SYMBL(4)
CALL SIZES(2.0)
:

```

WARNING

Serious consequences can result from including these calls within the user application program. This can be demonstrated by including the following call within the program of Figure 10,

```
CALL VBARST(4,46,25)
```

instead of the call

```
CALL VBARST(4,46,0)
```

as shown. These subroutine calls are not recommended to the novice programmer of the interactive computer graphics terminal system.

D. Subroutine INTCRT

Subroutine INTCRT performs the initialization function for the interactive computer graphics terminal system. Subroutine INTCRT contains call statements to other subprogram routines which initiates the hardware components by resetting the Xerox Model 7611 COC controller

and checking that it is switched on. External interrupts 6 and 7 are centrally connected and various software counters are initialized. Also, calls to subroutines are performed to initialize the Tektronix Model 4002A graphics computer terminal hardware and the Plot-10 software system. The one call to subroutine INTCRT within a main program or a subprogram routine replaces the three necessary (required) calling statements to subprograms ST7611, INITT, and BINITT. A message is output to the CRT display screen that the program is ready and that a 'C' control character is required as input from the display keyboard to continue.

Calling Sequence:

CALL INTCRT(KAG2)

where:

KAG2 - An integer parameter (variable or value) denoting that the advanced graphing II software package is to be initialized.

Example of Usage:

```

:
:
CALL INTCRT(1)
:
:
```

Input:

None.

Output:

The output resulting to the CRT display screen as a consequence of executing subroutine INTCRT is shown in Figure 7.

External Subroutine Required:

BINITT	ERASE	INITT
CHARRD	HITLES	ST7611

A listing of the subroutine INTCRT is shown in Figure 8.

4002A ICGTS PROGRAM READY,
TYPE C TO CONTINUE.

Figure 7. CRT display output from subroutine INTCRT.

```

1:      SUBROUTINE INTCRT(KAG2)
2:      DIMENSION LAB4(5)
3:      DATA LAB4 / 'TYPE C TO CONTINUE. ' /
4: C *** * * * *
5: C ***      USER INITIALIZATION OF I C G T S      ***
6: C ***      BY: LARMON S. ISSM      ***
7: C ***      1 MARCH 1976      ***
8: C *** * * * *
9:      10 CALL ST7611
10:     CALL INITT(120)
11:     IF(KAG2.EQ.0) CALL BINITT
12:     CALL HIT_ES(1,200,400,26,'4002A ICGTS PROGRAM READY, ' )
13:     CALL HIT_ES(1,200,370,19,LAB4)
14:     CALL CHARD(510)
15:     CALL ERASE
16:     RETURN
17: C *** * * * *
18: C ***      USER FINALIZATION OF I C G T C      ***
19: C *** * * * *
20:     ENTRY CRTFIN
21:     20 CALL ERASE
22:     CALL HIT_ES(1,200,400,30,'4002A ICGTS PROGRAM COMPLETED, ' )
23:     CALL HIT_ES(1,200,370,19,LAB4)
24:     CALL CHARD(520)
25:     CALL ERASE
26:     CALL FINITT(0,740)
27:     CALL ST7611
28:     RETURN
29:     END

```

Figure 8. Listing of subroutines INTCRT and CRTFIN.

E. Subroutine CRTFIN

Subroutine CRTFIN performs the terminating function for the interactive computer graphics terminal system. A message is output to the CRT display screen that the program is completed and requires a 'C' input from the keyboard to continue. The CRT display is erased (cleared) and the cursor moved to the home (0,740) position. The I/O activity from/to the keyboard/display through the Xerox Model 7611 COC controller is terminated and the centrally connected interrupts (6 and 7) are disconnected.

Calling Sequence:

CALL CRTFIN

Parameter(s) Entered:

None.

Example of Usage:

```
      :  
      :  
      CALL CRTFIN  
      :  
      :
```

External Subprograms Required:

```
CHARRD  
ERASE  
FINITT  
HTLES  
HT7611
```

Output:

The output to the CRT display screen as a consequence of subroutine CRTFIN is shown in Figure 9.

The calling statement to subroutine CRTFIN in the main program or a subprogram routine replaces the necessary (required) three calling statements to the subroutines HOME or MOVABS, FINITT, and HT7611. Subroutine CRTFIN is an entry point in subroutine INTCRT.

Input:

None.

A listing of the subroutine CRTFIN is shown in Figure 9.

V. AN APPLICATION PROGRAM AND ITS EXECUTION

This section presents a typical user application program which uses the interactive computer graphics terminal system for a portion of the output result. This program illustrates the usage of the graphic display annotation and control subroutines that have been developed and discussed in Section IV. Most of the examples given in Section IV have been used within the main program contained in this section. Other examples have been included, for comparison purposes only, to compare these techniques and methods with the customary practice used to annotate and control graphic displays heretofore. A listing of the main program, which contains the calling statements to the annotation and control subroutine subprograms, is shown in Figure 10.

4002A ICGTS PROGRAM COMPLETED,
TYPE C TO CONTINUE.

Figure 9. CRT display output from subroutine CRTFIN.

```

1:      REAL*8 RNDM1, RNDM2, E1
2:      DIMENSION YNJM(15), XDAT(15)
3:      DATA YNJM / 15*0.0 /
4:      DATA XDAT / -3.50,-3.00,-2.50,-2.00,-1.50,-1.00,-0.50,0.0,0.50,
5:      1 1.00,1.50,2.00,2.50, 3.00, 3.50 /
6:      IX = 1000
7:      PRINT 15
8:      PRINT 20
9:      DO 10 I = 1,1000
10:     CALL RANDJ(IX,IY,RNDM1)
11:     IF(I .LE. 25) PRINT 25,I,IX,IY,RNDM1
12:     CALL RANDJ(IX,IY,RNDM2)
13:     E1 = DSQRT(-2.000*DL98(RNDM1))*DC98(6.283185307200*RNDM2)
14:     IF(I .LE. 25) PRINT 25,I,IX,IY,RNDM2,E1
15:     ERN = SNGL(E1)
16:     XLLIM = -3.25
17:     XULIM = -2.75
18:     DO 100 J = 2,14
19:     IF(ERN .LT. -3.25) YNJM(1) = YNJM(1) + 1.0
20:     IF(ERN .GE. 3.25) YNJM(15) = YNJM(15) + 1.0
21:     IF(ERN .GE. XLLIM .AND. ERN .LT. XULIM) YNJM(J) = YNJM(J) + 1.0
22:     XLLIM = XLLIM + 0.5
23:     XULIM = XULIM + 0.5
24:   100 CONTINUE
25:   10 CONTINUE
26:   PRINT 15
27:   DO 11 N = 1,15
28:   PRINT 30,N,XDAT(N),YNJM(N)
29:   11 CONTINUE
30:   PRINT 15
31:   12 CONTINUE
32: C *** PLOT THE DATA ***
33:   CALL INTCRT(1)
34:   CALL NPTS(15)
35:   CALL LINE(2)
36:   CALL XFRM(2)
37:   CALL YFRM(2)
38:   CALL X4FRM(2)
39:   CALL Y4FRM(2)
40:   CALL VBARST(4,46,0)
41:   CALL CHECK(XDAT,YNJM)
42:   CALL DISPLAY(XDAT,YNJM)
43:   CALL LINE(14)
44:   CALL CPL9T(XDAT,YNJM)
45:   CALL HTITLE(1,300,30,24,'RANGE OF RANDOM NUMBERS.1')
46:   CALL HTITLE(2,25,600,25,'FREQUENCY OF DISTRIBUTION')
47:   CALL HTITLE(3,200,730,38,'HISTOGRAM OF RANDOM NUMBER GENERATION')
48:   CALL FRAME
49:   CALL CHARRD(512)
50:   CALL CRTFIN
51:   CALL F3$RLS(19V      ' )
52:   CALL EXIT
53:   15 FORMAT (1H1,/,/)
54:   20 FORMAT(14X,14I,5X,24IX,10X,24IY,6X,134RANDOM NUMBER)
55:   25 FORMAT(10X,I5,I12,I12,20I5.5)
56:   30 FORMAT(10X,I3,2E15.5)
57:   END

```

Figure 10. Listing of the main program.

The primary purpose of this program is to generate a series of random variables (in this case, 1000) and to plot the output result in the form of a histogram (see Reference 13 for a discussion of a histogram plot). The program uses a random number generated with a uniform distribution by a subroutine to obtain a random number with a Gaussian distribution (zero-mean, unity-variance) using the Box-Muller transformation technique. The random number generator is subroutine RANDU. Subroutine RANDU generates random numbers with a uniform distribution in the closed set [0,1]. The listing of the subroutine RANDU, which is based on the recurrence formula or multiplicative method, is shown in Figure 11.

```

1:      SUBROUTINE RANDU(IX,IY,YF_)
2:      REAL*8 YF_
3:      IY = IX*65539
4:      IF(IY) 5,6,6
5:      5 IY = IY+2147483647+1
6:      6 YF_ = IY
7:      YF_ = YF_*.4656613E-9
8:      IX = IY
9:      RETURN
10:     END

```

Figure 11. Listing of subroutine RANDU.

All programs that are written for and executed on the Xerox Sigma 5 analog coupler driver simulation facility are under control of the HRBM operating system. The necessary job control commands that are required by the HRBM operating system are shown in order in Figure 12. The main

```

!JOB RANDOM,NUMBERTEST
!FORTRAN SI,LS,G0,BC(25),NS
*****
**                                     **
**               USER'S APPLICATION PROGRAM               **
**               AND SUBROUTINES                           **
**               GO HERE.                                   **
**                                     **
*****
!ASSIGN (M:L0,LPA02),NOVFC
!ASSIGN (M:LL,LPA02),NOVFC
!DLAD (TEMP,450),(UDCR,1),(FORE,2300),(LIB,USER,SYSTEM),(MAP)
:ROOT (FILE,BT,G0,E00),(FILE,D6,M0CA62B0,E00),(FILE,D6,AG2FILB0,E00)
:ASSIGN (F:6,LPA05)
!FG
!RGV
!FIN

```

Figure 12. Listing of job control commands.

program and subroutine RANDU are compiled by the extended Fortran IV compiler, loaded by the system processor overlay loader "OLOAD" from the "GO" file onto the "OV" file along with the required TCS Plot-10 files, MOCAG2BO and AG2FILBO, and the library of subroutine subprograms. Then, the program is executed in the foreground area of computer memory. The resulting outputs from the execution of the program are shown in Figures 13 through 17. Figures 13, 14, and 15 are the outputs to the Tektronix 4002A CRT display area. The output listings to the foreground line printer are shown in Figures 16 and 17.

An alternate form of the graphic display for the same basic data may be obtained by making a few modifications to the Fortran statements shown in Figure 10. These modifications are:

- a) To statements 40, 41, and 42.

```

      :
      :
40:      CALL HBARST(4,37,0)
41:      CALL CHECK(YNUM,XDAT)
42:      CALL DSPLAY(YNUM,XDAT)
      :
      :

```

- b) To statements 44, 45, and 46.

```

      :
      :
44:      CALL CPLOT(YNUM,XDAT)
45:      CALL HITLES(1,300,30,25,'FREQUENCY OF
      DISTRIBUTION')
46:      CALL HITLES(2,25,600,24,'RANGE OF RANDOM
      NUMBERS. ')
      :
      :

```

The resulting output to the CRT display area will appear as shown in Figure 18.

VI. RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

This section presents the conclusions and comments concerning the annotation and control subroutines for graphic displays previously discussed in Section IV of this report. The graphic display output resulting from the execution of a typical user's application program using these techniques and methods has already been described in Section V; however, their use and application extends directly to the larger graphic display utilization of application programs such as the CLGP, PATRIOT (SAM-D), and SIG-D.

4002A ICGTS PROGRAM READY,
TYPE C TO CONTINUE.

Figure 13. CRT display output by calling
INTCRT in the main program.

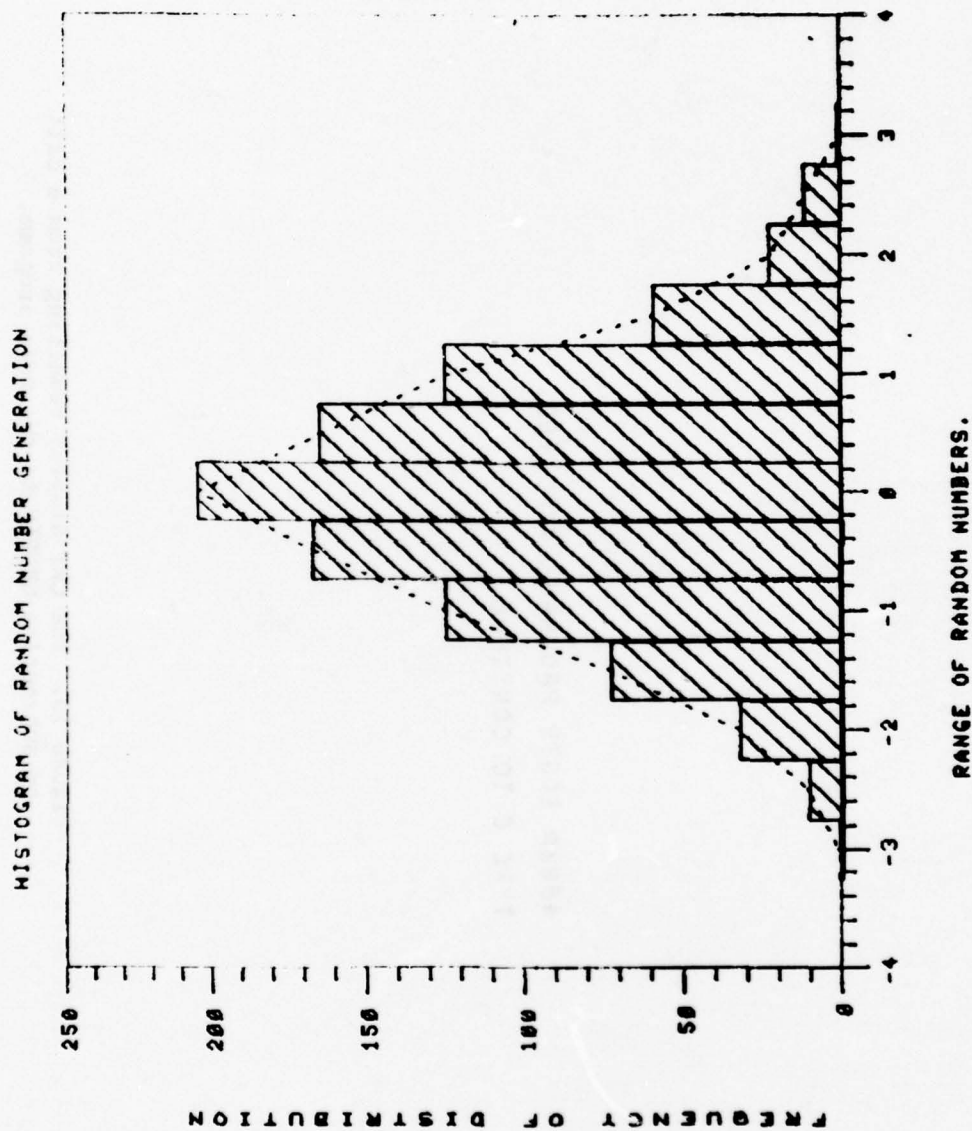


Figure 14. A CRT display of the random number histogram.

4002A ICGTS PROGRAM COMPLETED,
TYPE C TO CONTINUE.

Figure 15. The CRT display resulting from a call to subroutine CRTFIN in the main program.

	IX	IY	RANDOM NUMBER	
1	65539000	65539000	.305190-01	
1	333225000	333225000	.183110 00	.107790 01
2	1769499000	1769499000	.823990 00	
2	635518056	635518056	.295940 00	-.177120 00
3	772510224	772510224	.359730 00	
3	1062336488	1062336488	.494370 00	-.142920 01
4	1572423560	1572423560	.732220 00	
4	2015632616	2015632616	.938600 00	.731500 00
5	89413304	89413304	.416360-01	
5	1723139112	1723139112	.802400 00	.815220 00
6	944180344	944180344	.433670 00	
6	894248296	894248296	.416420 00	-.110920 01
7	1162833976	1162833976	.541490 00	
7	1076252840	1076252840	.501170 00	-.110760 01
8	286373552	286373552	.133630 00	
8	625530344	625530344	.291200 00	-.514630 00
9	1170375096	1170375096	.545900 00	
9	1302477480	1302477480	.648420 00	-.556420 00
10	2116456312	2116456312	.785550 00	
10	166440552	166440552	.775050-01	.150780 00
11	1277881336	1277881336	.575060 00	
11	1874403752	1874403752	.872840 00	.710620 00
12	1892002136	1892002136	.881450 00	
12	930220902	930220902	.433170 00	-.458730 00
13	1430162616	1430162616	.655970 00	
13	208905768	208905768	.172700-01	.738420 00
14	1266872952	1266872952	.580930 00	
14	1426118504	1426118504	.654990 00	-.528030 00
15	1449821752	1449821752	.675130 00	
15	158831272	158831272	.733520-01	.792400 00
16	789493752	789493752	.367540 00	
16	1159997416	1159997416	.540170 00	-.136990 01
17	2002024376	2002024376	.732270 00	
17	1572169512	1572169512	.732100 00	-.420380-01
18	4732240	4732240	.220360-00	
18	911253608	911253608	.424340 00	-.311000 01
19	1129963832	1129963832	.526180 00	
19	725984168	725984168	.338760 00	-.595530 00
20	628681464	628681464	.292750 00	
20	1533198568	1533198568	.713950 00	-.352000 00
21	1393574584	1393574584	.648930 00	
21	1005111336	1005111336	.468040 00	-.911230 00
22	2078431352	2078431352	.767860 00	
22	1277102440	1277102440	.594700 00	-.211730 00
23	1841634360	1841634360	.957580 00	
23	1703367848	1703367848	.793100 00	.148600 00
24	87948702	87948702	.400540-01	
24	229767656	229767656	.104990 00	.197700 01
25	587066808	587066808	.273370 00	
25	1454491944	1454491944	.677300 00	-.710350 00

Figure 16. Line printer listing of the random numbers.

1	--35000E 01	.00000E 00
2	--30000E 01	.10000E 01
3	--25000E 01	.11000E 02
4	--20000E 01	.33000E 02
5	--15000E 01	.73000E 02
6	--10000E 01	.12500E 03
7	--50000E 00	.16700E 03
8	.00000E 00	.20500E 03
9	.50000E 00	.16500E 03
10	.10000E 01	.12500E 03
11	.15000E 01	.59000E 02
12	.20000E 01	.23000E 02
13	.25000E 01	.12000E 02
14	.30000E 01	.10000E 01
15	.35000E 01	.00000E 00

Figure 17. Line printer listing of the random number histogram data.

As can be observed from the application program presented in Section V, it can be concluded that graphic displays may be annotated and controlled more easily by the techniques and methods presented in this report than has been possible within past programs. Additionally, these methods and techniques produce no affects upon the output resulting from the execution of user's application programs written in the past that utilizes the interactive computer graphics terminal system. However, the use of these subroutines would lessen the cost and shorten the time frame for obtaining properly annotated graphic displays. It is recommended that these programming practices and procedures be adopted in future user application programs which involve the interactive compute graphics terminal system.

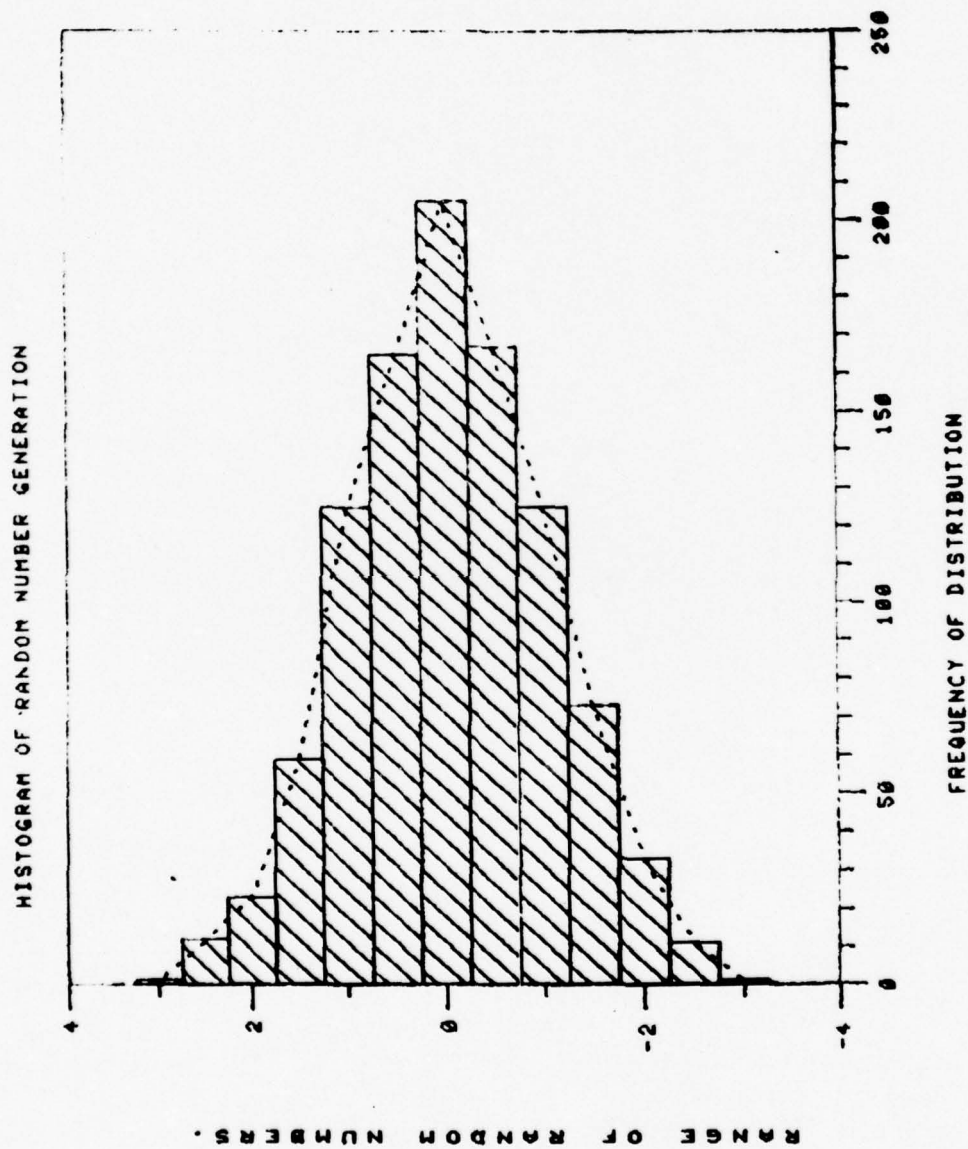


Figure 18. An alternate CRT display output.

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Appendix A: CHARACTER CODE CONVERSION

This appendix addresses the problem and the process of character code conversion between the ASCII character codes for the Tektronix 4002A graphic computer terminal and the EBCDIC for the character codes of the Xerox Sigma 5 digital computer. The primary purpose of this appendix is to show that conversion from ASCII to EBCDIC can be performed, and vice-versa, as well as to determine what character codes in ASCII/EBCDIC are converted to what EBCDIC/ASCII character codes by the COC software package.

Table A-1 presents the possible 128 ASCII character codes and their functions for the Tektronix 4002A graphic computer terminal in the various formats; such as binary, decimal integers, and graphical alphanumerics. Figure A-1 depicts the output to the CRT display area resulting from these 128 character codes being transmitted to the display area by the Sigma 5 digital computer. The line printer listing of these same 128 character codes upon being converted from ASCII to EBCDIC are contained in Table A-2. These outputs and code conversions were accomplished by executing the main program as shown in the listing of Figure A-2 with the aid of the Tektronix Plot-10 and the COC software packages. It should be readily observed that a majority of the ASCII character codes are converted to the EBCDIC code for a blank space (40_{16} or 64_{10}) by the COC software package; also, that the results returned from the Fortran function call to "NEBCD" is contained in the last byte (rightmost) of the word.

In a similar fashion, the 256 possible EBCDIC character codes were converted to ASCII character codes by the COC software package, transmitted through the Xerox Model 7611 COC device by the Sigma 5 digital computer, to the Tektronix 4002A CRT display screen. The resulting output to the CRT display area is shown in Figure A-3, while Table A-3 presents the line printer output listing for the program execution. Again, it is observable that a majority of the EBCDIC character codes are converted by the COC software package to the ASCII character code of 00_{16} , which is a "NUL" character. The main program to accomplish this EBCDIC to ASCII conversion is depicted as the listing shown in Figure A-4. Observe that not all alphanumeric symbols displayed on the CRT display area are printable on the line printer.

TABLE A-1. 4002A GRAPHIC COMPUTER TERMINAL

ASCII CODE FUNCTIONS

BITS b ₇ b ₆ b ₅ b ₄				CONTROL				HIGH ORDER X & Y				LOW ORDER X				LOW ORDER Y			
b ₇	b ₆	b ₅	b ₄																
0	0	0	0	NUL	0	DLE	16	SP	32	0	48	@	64	P	80		96	p	112
0	0	0	1	SOH	1	DC1	17	!	33	1	49	A	65	Q	81	a	97	q	113
0	0	1	0	STX	2	DC2	18	"	34	2	50	B	66	R	82	b	98	r	114
0	0	1	1	ETX	3	DC3	19	#	35	3	51	C	67	S	83	c	99	s	115
0	1	0	0	EOT	4	DC4	20	\$	36	4	52	D	68	T	84	d	100	t	116
0	1	0	1	ENQ	5	NAK	21	%	37	5	53	E	69	U	85	e	101	u	117
0	1	1	0	ACK	6	SYN	22	&	38	6	54	F	70	V	86	f	102	v	118
0	1	1	1	BEL	7	ETB	23	'	39	7	55	G	71	W	87	g	103	w	119
1	0	0	0	BS	8	CAN	24	(	40	8	56	H	72	X	88	h	104	x	120
1	0	0	1	HT	9	EM	25	)	41	9	57	I	73	Y	89	i	105	y	121
1	0	1	0	LF	10	SUB	26	*	42	:	58	J	74	Z	90	j	106	z	122
1	0	1	1	VT	11	ESC	27	+	43	;	59	K	75	[	91	k	107	{	123
1	1	0	0	FF	12	FS	28	,	44	<	60	L	76	\	92	l	108	|	124
1	1	0	1	CR	13	GS	29	-	45	=	61	M	77	]	93	m	109	}	125
1	1	1	0	SO	14	RS	30	.	46	>	62	N	78	^	94	n	110	~	126
1	1	1	1	SI	15	US	31	/	47	?	63	O	79	_	95	o	111	RUB OUT	127

* PRECEDED BY ESC
 1 PRECEDED BY SELECTION OF COMPOSE MODE
 2 TTY TRANSMIT ONLY

GRAPHIC
INPUT

!"#\$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMN O PQRSTU VWXYZ[\]^_
'`abcdefghijklmnopqrstuvwxyz{|}~

Figure A-1. ASCII character codes output to CRT display.

TABLE A-2. LINE PRINTER LISTING OF ASCII CHARACTER CODES CONVERTED TO EBCDIC

①	②	③	④	①	②	③	④	①	②	③	④	①	②	③	④
0	00	40		96	50	40		32	20	40		97	51	40	
1	01	40		97	51	40		33	21	5A		98	52	5A	
2	02	40		98	52	40		34	22	7F		99	53	7F	
3	03	40		99	53	40		35	23	78		100	54	78	
4	04	40		100	54	40		36	24	53		101	55	53	
5	05	40		101	55	40		37	25	5C		102	56	5C	
6	06	40		102	56	40		38	26	5D		103	57	5D	
7	07	40		103	57	40		39	27	7D		104	58	7D	
8	08	40		104	58	40		40	28	40		105	59	40	
9	09	40		105	59	40		41	29	5D		106	5A	5D	
10	0A	40		106	5A	40		42	2A	5C		107	5B	5C	
11	0B	40		107	5B	40		43	2B	4E		108	5C	4E	
12	0C	40		108	5C	40		44	2C	53		109	5D	53	
13	0D	40		109	5D	40		45	2D	50		110	5E	50	
14	0E	40		110	5E	40		46	2E	43		111	5F	43	
15	0F	40		111	5F	40		47	2F	4B		112	60	4B	
16	10	40		112	60	40		48	30	51		113	61	51	
17	11	40		113	61	40		49	31	52		114	62	52	
18	12	40		114	62	40		50	32	53		115	63	53	
19	13	40		115	63	40		51	33	54		116	64	54	
20	14	40		116	64	40		52	34	55		117	65	55	
21	15	40		117	65	40		53	35	56		118	66	56	
22	16	40		118	66	40		54	36	57		119	67	57	
23	17	40		119	67	40		55	37	58		120	68	58	
24	18	40		120	68	40		56	38	59		121	69	59	
25	19	40		121	69	40		57	39	7A		122	70	7A	
26	1A	40		122	70	40		58	3A	5E		123	71	5E	
27	1B	40		123	71	40		59	3B	7E		124	72	7E	
28	1C	40		124	72	40		60	3C	4C		125	73	4C	
29	1D	40		125	73	40		61	3D	7E		126	74	7E	
30	1E	40		126	74	40		62	3E	6E		127	75	6E	
31	1F	40		127	75	40		63	3F	6F					

Legend:

① Decimal integer

② ASCII hexadecimal code

③ EBCDIC hexadecimal code

④ Line printer/CRT display alphanumeric symbol


```

1:      DATA LDIGIC / 8700000000 /
2:      DATA INC / 8700000001 /
3:      C
4:      5 CONTINUE
5:      CALL INTORT(1)
6:      C
7:      CALL ERASE
8:      CALL M9VABS(0,700)
9:      CALL NEWLIN
10:     PRINT 20
11:     CALL ANM9DE
12:     CALL DBLSIZ
13:     LDIG = LDIGIC
14:     C
15:     DO 10 I = 1,128
16:     LCHR = NEBCD(LDIG,4)
17:     KDIG = LCHR
18:     PRINT 15,LDIG,LDIG,LCHR,KDIG
19:     IF(I .GT. 32) CALL WT7611(LDIG)
20:     IF(I .EQ. 32) CALL NEWLIN
21:     IF(I .EQ. 32) PRINT 20
22:     IF(I .EQ. 64) CALL NEWLIN
23:     IF(I .EQ. 64) PRINT 20
24:     IF(I .EQ. 96) CALL NEWLIN
25:     IF(I .EQ. 96) PRINT 20
26:     IF(I .EQ. 128) CALL NEWLIN
27:     IF(I .EQ. 128) PRINT 20
28:     LDIG = LDIG + INC
29:     10 CONTINUE
30:     CALL NRMSIZ
31:     CALL CHARCD(K5)
32:     C
33:     CALL CRTFIN
34:     C
35:     CALL F9$RLS('9V      ')
36:     CALL EXIT
37:     15 FORMAT(10X,I5,3X,Z2,3X,72,A4)
38:     20 FORMAT(141,/,/,/,/)
39:     END

```

Figure A-2. Listing of main program for ASCII/EBCDIC character code conversion.

\ . < (+ [& ! \$ *) ;
- / , &] > ? : # @ ' = "

A B C D E F G H I J K L M N O P Q R
S T U V W X Y Z 0 1 2 3 4 5 6 7 8 9

Figure A-3. Results of EBCDIC character codes converted to ASCII and output to the CRT display area.

TABLE A-3. LINE PRINTER LISTING OF EBCDIC CHARACTER CODES

(1)	95	(4)	20
(2)	60	(3)	21
(3)	97	(4)	22
(4)	61	(3)	23
(1)	98	(4)	24
(2)	62	(3)	25
(3)	99	(4)	26
(4)	63	(3)	27
(1)	100	(4)	28
(2)	64	(3)	29
(3)	101	(4)	30
(4)	65	(3)	31
(1)	102	(4)	32
(2)	66	(3)	33
(3)	103	(4)	34
(4)	67	(3)	35
(1)	104	(4)	36
(2)	68	(3)	37
(3)	105	(4)	38
(4)	69	(3)	39
(1)	106	(4)	40
(2)	70	(3)	41
(3)	107	(4)	42
(4)	71	(3)	43
(1)	108	(4)	44
(2)	72	(3)	45
(3)	109	(4)	46
(4)	73	(3)	47
(1)	110	(4)	48
(2)	74	(3)	49
(3)	111	(4)	50
(4)	75	(3)	51
(1)	112	(4)	52
(2)	76	(3)	53
(3)	113	(4)	54
(4)	77	(3)	55
(1)	114	(4)	56
(2)	78	(3)	57
(3)	115	(4)	58
(4)	79	(3)	59
(1)	116	(4)	60
(2)	80	(3)	61
(3)	117	(4)	62
(4)	81	(3)	63
(1)	118	(4)	64
(2)	82	(3)	65
(3)	119	(4)	66
(4)	83	(3)	67
(1)	120	(4)	68
(2)	84	(3)	69
(3)	121	(4)	70
(4)	85	(3)	71
(1)	122	(4)	72
(2)	86	(3)	73
(3)	123	(4)	74
(4)	87	(3)	75
(1)	124	(4)	76
(2)	88	(3)	77
(3)	125	(4)	78
(4)	89	(3)	79
(1)	126	(4)	80
(2)	90	(3)	81
(3)	127	(4)	82
(4)	91	(3)	83
(1)	128	(4)	84
(2)	92	(3)	85
(3)	129	(4)	86
(4)	93	(3)	87
(1)	130	(4)	88
(2)	94	(3)	89
(3)	131	(4)	90
(4)	95	(3)	91
(1)	132	(4)	92
(2)	96	(3)	93
(3)	133	(4)	94
(4)	97	(3)	95
(1)	134	(4)	96
(2)	98	(3)	97
(3)	135	(4)	98
(4)	99	(3)	99
(1)	136	(4)	100
(2)	100	(3)	101
(3)	137	(4)	102
(4)	101	(3)	103
(1)	138	(4)	104
(2)	102	(3)	105
(3)	139	(4)	106
(4)	103	(3)	107
(1)	140	(4)	108
(2)	104	(3)	109
(3)	141	(4)	110
(4)	105	(3)	111
(1)	142	(4)	112
(2)	106	(3)	113
(3)	143	(4)	114
(4)	107	(3)	115
(1)	144	(4)	116
(2)	108	(3)	117
(3)	145	(4)	118
(4)	109	(3)	119
(1)	146	(4)	120
(2)	110	(3)	121
(3)	147	(4)	122
(4)	111	(3)	123
(1)	148	(4)	124
(2)	112	(3)	125
(3)	149	(4)	126
(4)	113	(3)	127
(1)	150	(4)	128
(2)	114	(3)	129
(3)	151	(4)	130
(4)	115	(3)	131
(1)	152	(4)	132
(2)	116	(3)	133
(3)	153	(4)	134
(4)	117	(3)	135
(1)	154	(4)	136
(2)	118	(3)	137
(3)	155	(4)	138
(4)	119	(3)	139
(1)	156	(4)	140
(2)	120	(3)	141
(3)	157	(4)	142
(4)	121	(3)	143
(1)	158	(4)	144
(2)	122	(3)	145
(3)	159	(4)	146
(4)	123	(3)	147
(1)	160	(4)	148
(2)	124	(3)	149
(3)	161	(4)	150
(4)	125	(3)	151
(1)	162	(4)	152
(2)	126	(3)	153
(3)	163	(4)	154
(4)	127	(3)	155
(1)	164	(4)	156
(2)	128	(3)	157
(3)	165	(4)	158
(4)	129	(3)	159
(1)	166	(4)	160
(2)	130	(3)	161
(3)	167	(4)	162
(4)	131	(3)	163
(1)	168	(4)	164
(2)	132	(3)	165
(3)	169	(4)	166
(4)	133	(3)	167
(1)	170	(4)	168
(2)	134	(3)	169
(3)	171	(4)	170
(4)	135	(3)	171
(1)	172	(4)	172
(2)	136	(3)	173
(3)	173	(4)	174
(4)	137	(3)	175
(1)	174	(4)	176
(2)	138	(3)	177
(3)	175	(4)	178
(4)	139	(3)	179
(1)	176	(4)	180
(2)	140	(3)	181
(3)	177	(4)	182
(4)	141	(3)	183
(1)	178	(4)	184
(2)	142	(3)	185
(3)	179	(4)	186
(4)	143	(3)	187
(1)	180	(4)	188
(2)	144	(3)	189
(3)	181	(4)	190
(4)	145	(3)	191
(1)	182	(4)	192
(2)	146	(3)	193
(3)	183	(4)	194
(4)	147	(3)	195
(1)	184	(4)	196
(2)	148	(3)	197
(3)	185	(4)	198
(4)	149	(3)	199
(1)	186	(4)	200
(2)	150	(3)	201
(3)	187	(4)	202
(4)	151	(3)	203
(1)	188	(4)	204
(2)	152	(3)	205
(3)	189	(4)	206
(4)	153	(3)	207
(1)	190	(4)	208
(2)	154	(3)	209
(3)	191	(4)	210
(4)	155	(3)	211
(1)	192	(4)	212
(2)	156	(3)	213
(3)	193	(4)	214
(4)	157	(3)	215
(1)	194	(4)	216
(2)	158	(3)	217
(3)	195	(4)	218
(4)	159	(3)	219
(1)	196	(4)	220
(2)	160	(3)	221
(3)	197	(4)	222
(4)	161	(3)	223
(1)	198	(4)	224
(2)	162	(3)	225
(3)	199	(4)	226
(4)	163	(3)	227
(1)	200	(4)	228
(2)	164	(3)	229
(3)	201	(4)	230
(4)	165	(3)	231
(1)	202	(4)	232
(2)	166	(3)	233
(3)	203	(4)	234
(4)	167	(3)	235
(1)	204	(4)	236
(2)	168	(3)	237
(3)	205	(4)	238
(4)	169	(3)	239
(1)	206	(4)	240
(2)	170	(3)	241
(3)	207	(4)	242
(4)	171	(3)	243
(1)	208	(4)	244
(2)	172	(3)	245
(3)	209	(4)	246
(4)	173	(3)	247
(1)	210	(4)	248
(2)	174	(3)	249
(3)	211	(4)	250
(4)	175	(3)	251
(1)	212	(4)	252
(2)	176	(3)	253
(3)	213	(4)	254
(4)	177	(3)	255
(1)	214	(4)	256
(2)	178	(3)	257
(3)	215	(4)	258
(4)	179	(3)	259
(1)	216	(4)	260
(2)	180	(3)	261
(3)	217	(4)	262
(4)	181	(3)	263
(1)	218	(4)	264
(2)	182	(3)	265
(3)	219	(4)	266
(4)	183	(3)	267
(1)	220	(4)	268
(2)	184	(3)	269
(3)	221	(4)	270
(4)	185	(3)	271
(1)	222	(4)	272
(2)	186	(3)	273
(3)	223	(4)	274
(4)	187	(3)	275
(1)	224	(4)	276
(2)	188	(3)	277
(3)	225	(4)	278
(4)	189	(3)	279
(1)	226	(4)	280
(2)	190	(3)	281
(3)	227	(4)	282
(4)	191	(3)	283
(1)	228	(4)	284
(2)	192	(3)	285
(3)	229	(4)	286
(4)	193	(3)	287
(1)	230	(4)	288
(2)	194	(3)	289
(3)	231	(4)	290
(4)	195	(3)	291
(1)	232	(4)	292
(2)	196	(3)	293
(3)	233	(4)	294
(4)	197	(3)	295
(1)	234	(4)	296
(2)	198	(3)	297
(3)	235	(4)	298
(4)	199	(3)	299
(1)	236	(4)	300
(2)	200	(3)	301
(3)	237	(4)	302
(4)	201	(3)	303
(1)	238	(4)	304
(2)	202	(3)	305
(3)	239	(4)	306
(4)	203	(3)	307
(1)	240	(4)	308
(2)	204	(3)	309
(3)	241	(4)	310
(4)	205	(3)	311
(1)	242	(4)	312
(2)	206	(3)	313
(3)	243	(4)	314
(4)	207	(3)	315
(1)	244	(4)	316
(2)	208	(3)	317
(3)	245	(4)	318
(4)	209	(3)	319
(1)	246	(4)	320
(2)	210	(3)	321
(3)	247	(4)	322
(4)	211	(3)	323
(1)	248	(4)	324
(2)	212	(3)	325
(3)	249	(4)	326
(4)	213	(3)	327
(1)	250	(4)	328
(2)	214	(3)	329
(3)	251	(4)	330
(4)	215	(3)	331
(1)	252	(4)	332
(2)	216	(3)	333
(3)	253	(4)	334
(4)	217	(3)	335
(1)	254	(4)	336
(2)	218	(3)	337
(3)	255	(4)	338
(4)	219	(3)	339
(1)	256	(4)	340
(2)	220	(3)	341
(3)	257	(4)	342
(4)	221	(3)	343
(1)	258	(4)	344
(2)	222	(3)	345
(3)	259	(4)	346
(4)	223	(3)	347
(1)	260	(4)	348
(2)	224	(3)	349
(3)	261	(4)	350
(4)	225	(3)	351
(1)	262	(4)	352
(2)	226	(3)	353
(3)	263	(4)	354
(4)	227	(3)	355
(1)	264	(4)	356
(2)	228	(3)	357
(3)	265	(4)	358
(4)	229	(3)	359
(1)	266	(4)	360
(2)	230	(3)	361
(3)	267	(4)	362
(4)	231	(3)	363
(1)	268	(4)	364
(2)	232	(3)	365
(3)	269	(4)	366
(4)	233	(3)	367
(1)	270	(4)	368
(2)	234	(3)	369
(3)	271	(4)	370
(4)	235	(3)	371
(1)	272	(4)	372
(2)	236	(3)	373
(3)	273	(4)	374
(4)	237	(3)	375
(1)	274	(4)	376
(2)	238	(3)	377
(3)	275	(4)	378
(4)	239	(3)	379
(1)	276	(4)	380
(2)	240	(3)	381
(3)	277	(4)	382
(4)	241	(3)	383
(1)	278	(4)	384
(2)	242	(3)	385
(3)	279	(4)	386
(4)	243	(3)	387
(1)	280	(4)	388
(2)	244	(3)	389
(3)	281	(4)	390
(4)	245	(3)	391
(1)	282	(4)	392
(2)	246	(3)	393
(3)	283	(4)	394
(4)	247	(3)	395
(1)	284	(4)	396
(2)	248	(3)	397
(3)	285	(4)	398
(4)	249	(3)	399
(1)	286	(4)	400
(2)	250	(3)	401
(3)	287	(4)	402
(4)	251	(3)	403
(1)	288	(4)	404
(2)	252	(3)	405
(3)	289	(4)	406
(4)	253	(3)	407
(1)	290	(4)	408
(2)	254	(3)	409
(3)	291	(4)	41

Legend:

① Decimal integer

② EBCDIC hexadecimal code

③ ASCII hexadecimal code

④ Line printer/CRT display alphanumeric symbol

TABLE A-3. (Concluded).

(1)	128
(2)	80
(3)	00
(4)	
(1)	160
(2)	A0
(3)	00
(4)	
(1)	161
(2)	A1
(3)	00
(4)	
(1)	162
(2)	A2
(3)	00
(4)	
(1)	163
(2)	A3
(3)	00
(4)	
(1)	164
(2)	A4
(3)	00
(4)	
(1)	165
(2)	A5
(3)	00
(4)	
(1)	166
(2)	A6
(3)	00
(4)	
(1)	167
(2)	A7
(3)	00
(4)	
(1)	168
(2)	A8
(3)	00
(4)	
(1)	169
(2)	A9
(3)	00
(4)	
(1)	170
(2)	AA
(3)	00
(4)	
(1)	171
(2)	AB
(3)	00
(4)	
(1)	172
(2)	AC
(3)	00
(4)	
(1)	173
(2)	AD
(3)	00
(4)	
(1)	174
(2)	AE
(3)	00
(4)	
(1)	175
(2)	AF
(3)	00
(4)	
(1)	176
(2)	B0
(3)	00
(4)	
(1)	177
(2)	B1
(3)	00
(4)	
(1)	178
(2)	B2
(3)	00
(4)	
(1)	179
(2)	B3
(3)	00
(4)	
(1)	180
(2)	B4
(3)	00
(4)	
(1)	181
(2)	B5
(3)	00
(4)	
(1)	182
(2)	B6
(3)	00
(4)	
(1)	183
(2)	B7
(3)	00
(4)	
(1)	184
(2)	B8
(3)	00
(4)	
(1)	185
(2)	B9
(3)	00
(4)	
(1)	186
(2)	BA
(3)	00
(4)	
(1)	187
(2)	BB
(3)	00
(4)	
(1)	188
(2)	BC
(3)	00
(4)	
(1)	189
(2)	BD
(3)	00
(4)	
(1)	190
(2)	BE
(3)	00
(4)	
(1)	191
(2)	BF
(3)	00
(4)	

Legend:

① Decimal integer

② EBCDIC hexadecimal code

③ ASCII hexadecimal code

④ Line printer/CRT display
alphanumeric symbol


```

1:      DATA _LDIGIC / 8200000000 /
2:      DATA INC / 8200000001 /
3:      5 CONTINUE
4: C
5:      CALL INTERT(1)
6: C
7:      CALL ERASE
8:      CALL M9VABS(0,700)
9:      CALL NEWLIN
10:     CALL ANM9DE
11:     CALL DB_SIZ
12:     _LDIG = _LDIGIC
13:     PRINT 20
14: C
15:     DO 10 I = 1,256
16:     _LCHR = NASCII(_LDIG,4)
17:     <DIG = _LDIG
18:     IF(_LCHR .EQ. _LDIGIC) <DIG = 64
19:     PRINT 15,_LDIG,_DIG,_LCHR,<DIG
20:     CALL AT7611(_LCHR)
21:     IF(I .EQ. 32) CALL NEWLIN
22:     IF(I .EQ. 32) PRINT 20
23:     IF(I .EQ. 64) CALL NEWLIN
24:     IF(I .EQ. 64) PRINT 20
25:     IF(I .EQ. 96) CALL NEWLIN
26:     IF(I .EQ. 96) PRINT 20
27:     IF(I .EQ. 128) CALL NEWLIN
28:     IF(I .EQ. 128) PRINT 20
29:     IF(I .EQ. 160) CALL NEWLIN
30:     IF(I .EQ. 160) PRINT 20
31:     IF(I .EQ. 192) CALL NEWLIN
32:     IF(I .EQ. 192) PRINT 20
33:     IF(I .EQ. 224) CALL NEWLIN
34:     IF(I .EQ. 224) PRINT 20
35:     IF(I .EQ. 256) CALL NEWLIN
36:     IF(I .EQ. 256) PRINT 20
37:     _LDIG = _LDIG + INC
38: 10 CONTINUE
39:     CALL NRMSIZ
40:     CALL CHARRD(15)
41: C
42:     CALL CRTFIN
43: C
44:     CALL F9R2LS(19V      1)
45:     CALL EXIT
46: 15 FORMAT(10X,I5,3X,Z2,3X,Z2,A4)
47: 20 FORMAT(14I,/,/,/,/)
48:     END

```

Figure A-4. Listing of the main program for EBCDIC/ASCII character code conversion.

Appendix B. STANDARD OPERATING PROCEDURE FOR TEKTRONIX 4002A GRAPHIC COMPUTER TERMINAL TURN-ON

When first "powered-up" each day, the Tektronix 4002A graphic computer terminal user usually has difficulty in obtaining the first graphical display from a Xerox Sigma 5 digital computer program. To obtain this graphical display, the program has to be reexecuted, which is time consuming. To eliminate this difficulty in the future, it is suggested that the following standard operating procedure be adopted for "Turning-On" the Tektronix 4002A graphic computer terminal for the first time each day.

- 1) Turn the power switch ON, vertical to horizontal - clockwise. Allow to "Warm-Up" a few minutes.
- 2) Set the "On Line-Local" rocker switch to Local.
- 3) Set the "Direct-Scratch Pad" rocker switch to Scratch Pad.
- 4) Press the following keys:
 - a) Home.
 - b) Erase.
 - c) Space bar, to enter the scratch pad mode of operation.
 - d) Full, to clear the scratch pad area.
 - e) Enter information into the scratch pad area by pressing the desired keyboard keys.
 - f) Send, to send the information to the CRT (Cathode Ray Tube) screen.
 - g) To enter a full CRT screen of information, enter Line Feed and Return while in the scratch pad mode of operation; press and hold down the Space bar and Send keys while repeatedly pressing the Repeat key.
- 5) When Item 4 has been completed, press the following keys:
 - a) Space bar, to enter scratch pad mode.
 - b) Full, to clear the scratch pad area.
 - c) Home, to exit the scratch pad mode.
 - d) Erase, to clear the CRT screen.
 - e) Set the "On Line-Local" rocker switch to On Line.
 - f) Set the "Direct-Scratch Pad" rocker switch to Direct.
- 6) The Tektronix 4002A graphic computer terminal system is now ready for operation by an application program from the Xerox Sigma 5 digital computer.

7) If hard copies are to be obtained, turn-on the Tektronix 4601 Hard Copier Unit.

8) When the program has been completed, the CRT screen should be erased and the cursor beam returned to the home position.

Appendix C. COMPARISON OF PROGRAMMING METHODS BY EXAMPLES

This appendix compares the programming methods for annotating and controlling interactive graphic display plots. The main application program is contained in Figure C-1. This program contains essentially four identical graphic displays. Each display is annotated by a different technique and is produced by subroutine PLOTSD, which is shown in Figure C-2. The first programming example of the main program produces Figure C-3, which is the graphic display output produced by subroutine PLOTSD. It contains no annotations except for those output by the subroutine DATER.

Programming example number 2 of the main program is the Fortran statement numbers 40 through 56 of Figure C-1. This example is the customary manner in which interactive graphic displays have been annotated in the past. Observe that a large number of Fortran dimension and data statements are required as well as calls to subroutine MOVABS in order to annotate the graphic display by this example. Also, observe that the vertical annotations have not been rotated as they are in other examples. Figure C-4 shows the CRT display output from program example number 2.

Program example number 3, Fortran statements 58 through 72 of the main program, is almost identical to programming example number 2. However, it calls the subroutine RVTITL to rotate and place the vertical annotations. The resulting output to the CRT display area is contained in Figure C-5.

The program example number 4 of the main program is Fortran statements 74 through 83 of Figure C-1. This example uses the calls to subroutine HITLES to place the annotations on the interactive graphic display plots. This method is recommended in the future for all programs which contain outputs to the CRT display area, because no dimension and data statements are required in the main program. Figure C-6 is the output to the CRT display screen area resulting from the execution of program example number 4.

Although these four programming examples have been lumped together within one large application main program, they do represent the various techniques of graphic display annotations and the amount of programming effort involved.

- 1) No annotations, no effort involved by example 1.
- 2) Annotations by example 4, some effort involved, but not as much as required by examples 2 and 3.
- 3) Annotations by examples 2 and 3, the maximum amount of effort involved.

Notice that by removing the Fortran statements for each programming example along with the required dimension and data statements, four separate and distinct programs could be developed from these four examples.

Finally, Figure C-7 shows a listing of the subroutine DATER. The CRT display output as a result of a call to subroutine DATER is contained in Figure C-8.

Additionally, the calls to subroutine CHARRD in the main program permit the user/operator to perform adjustments on the Tektronix 4002A graphic computer terminal and/or the 4601 hard copier unit. The contrast control on the 4601 hard copier unit may be set too low (light), producing a copy as shown in Figure C-9, or set too high (dark), producing a copy as shown in Figure C-10. Likewise, the intensity control on the Tektronix 4002A graphic computer terminal may be set too low or too high, producing similar resulting copies as shown in Figures C-9 or C-10 also. Further, the supply of 4601 hard copy paper can be depleted while an application program is executing. Subroutine CHARRD allows the program to continue without hard copies being made, and/or the paper supply replenished in the 4601 hard copier unit.


```

63:      CALL HLABE(55,14L)
64:      CALL M9VABS(360,30)
65:      CALL HLABE(26,LABRV)
66:      CALL M9VABS(430,50)
67:      CALL HLABE(14,IVL)
68:      CALL M9VABS(200,720)
69:      DO 30 J = 1,55
70:      CALL HLABE(1,ASCII(IGDT,J))
71: 30 CONTINUE
72:      CALL CHARO(598)
73: C      PROGRAM EXAMPLE NUMBER 4.
74: 97 CONTINUE
75:      CALL PL9TSD(36,1.5)
76:      CALL HITLES(1,360,30,26,LABH)
77:      CALL HITLES(2,30,640,24,LABV)
78:      CALL HITLES(1,430,50,14,'TIME (SECONDS)')
79:      CALL HITLES(2, 60,600,20,'VELOCITY (FEET/SEC.)')
80:      CALL HITLES(1,200,720,55,'GRAPHICAL DISPLAY OF DEPENDENT VERSJS IN
81: 1DEPENDENT DATA.')
82:      CALL HITLES(1,200,10,55,IGDTST)
83:      CALL CHARO(597)
84: C
85:      CALL CHARO(510)
86: C      ICGTS FINALIZATION STATEMENTS
87:      CALL ERASE
88:      CALL FINITT(0,760)
89:      CALL HT7611
90: C
91:      CALL F38RLS(19V)
92:      CALL EXIT
93:      END

```

Figure C-1. (Concluded).

```

1:      SUBROUTINE PLOTSD(N9P,SF)
2:      DIMENSION X(101), S9X(100), C9X(100)
3:      DIMENSION C9XB(100), S9XB(100)
4:      DIMENSION I-L(36)
5:      DATA I-L / 32,42,84,72,69,32,71,82,65,80,72,73,67,65,76,32,68,73,
6:      1 83,80, 76,65,89,32,71,79,69,83,32,72,69,82,69,46,42,32 /
7:      DATA IGD / 0 /
8:      AMIN = +10000.0
9:      BMIN = AMIN
10:     AMAX = -10000.0
11:     BMAX = AMAX
12:     IF(IGD .NE. 0) G9 T9 11
13:     IGD = 1
14:     X(1) = 0.0
15:     D9 10 I = 1,N9P
16:     C9XB(I) = COS(X(I))
17:     S9XB(I) = SIN(X(I))
18:     X(I+1) = X(I) + 0.2617994
19:     X(I) = X(I)*57.29577951
20: 10 CONTINUE
21: 11 CONTINUE
22:     D9 12 I = 1,N9P
23:     C9X(I) = SF*C9XB(I)
24:     S9X(I) = SF*S9XB(I)
25: 12 CONTINUE
26:     CALL ERASE
27: X    CALL FRAME
28:     CALL NPTS(N9P)
29: X    CALL XFRM(3)
30: X    CALL YFRM(6)
31: X    CALL XYFRM(3)
32: X    CALL YMYFRM(3)
33:     CALL LINE(0)
34:     CALL SYMBL(0)
35:     CALL MMVX(X,AMIN,AMAX)
36:     CALL MMVX(C9X,BMIN,BMAX)
37:     CALL MMVX(S9X,BMIN,BMAX)
38:     CALL DLMX(AMIN,AMAX)
39:     CALL DLMY(BMIN,BMAX)
40:     CALL CHECK(X,C9X)
41:     CALL CHECK(X,S9X)
42:     CALL DISPLAY(X,S9X)
43:     D9 15 I = 1,N9P
44:     CALL MOVEA(X(I),C9X(I))
45:     CALL AMODE
46:     CALL LABEL(1,I-L(I))
47: 15 IF(NSTCK(I) .GE. 3) G9 T9 16
48: 16 CONTINUE
49:     CALL DATER
50:     RETURN
51:     END

```

Figure C-2. Listing of subroutine PLOTSD.

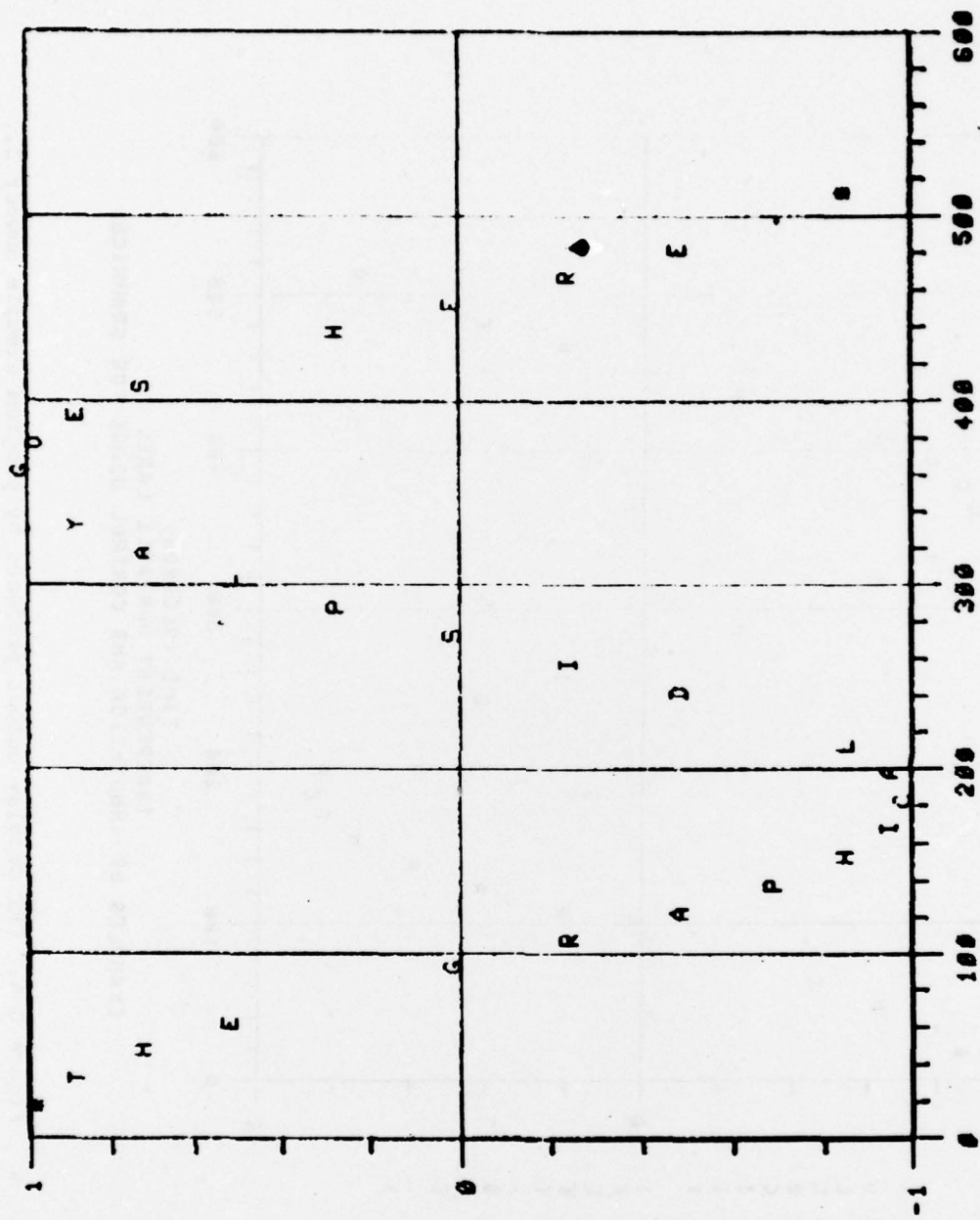


Figure C-3. Graphic display output by PLOTSD.

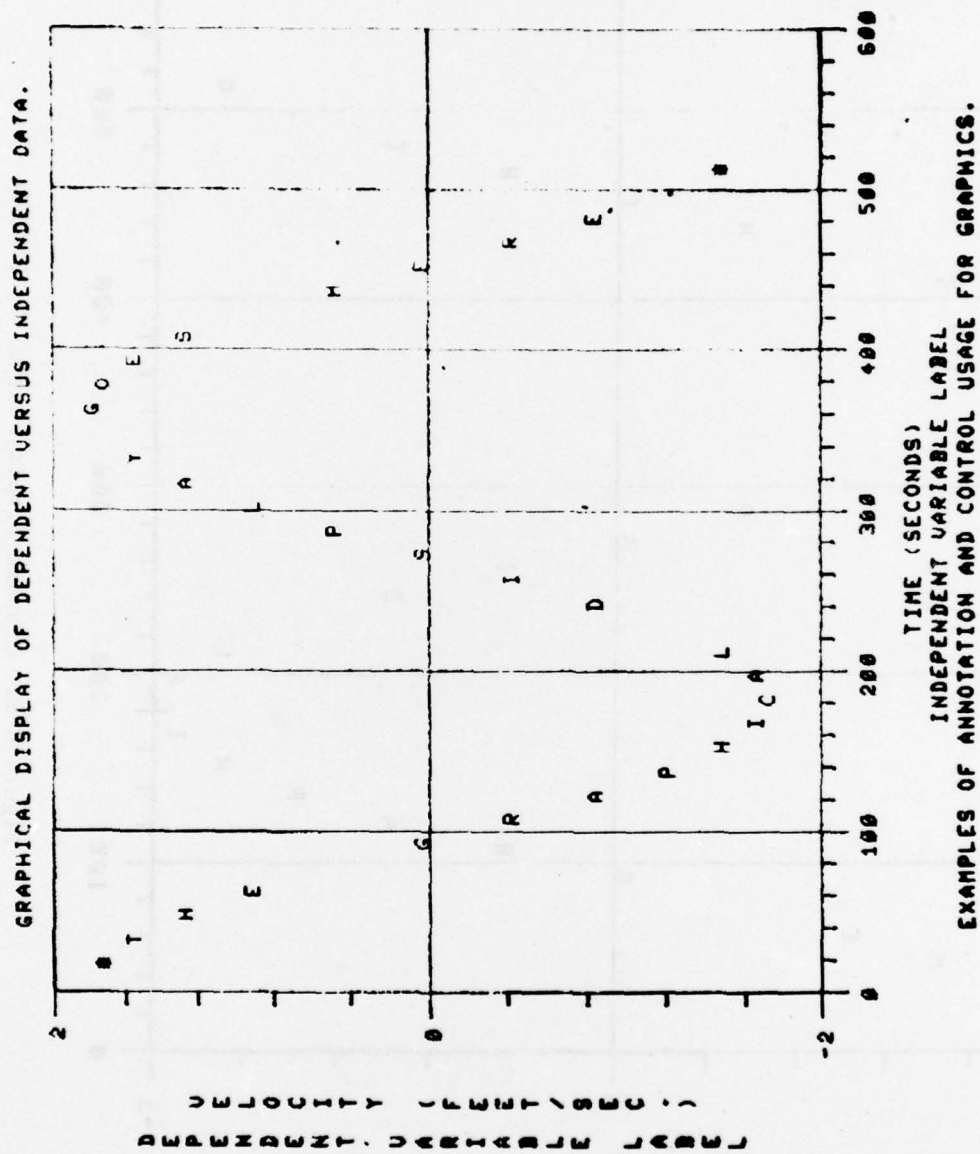


Figure C-4. CRT display output produced by program example number 2.

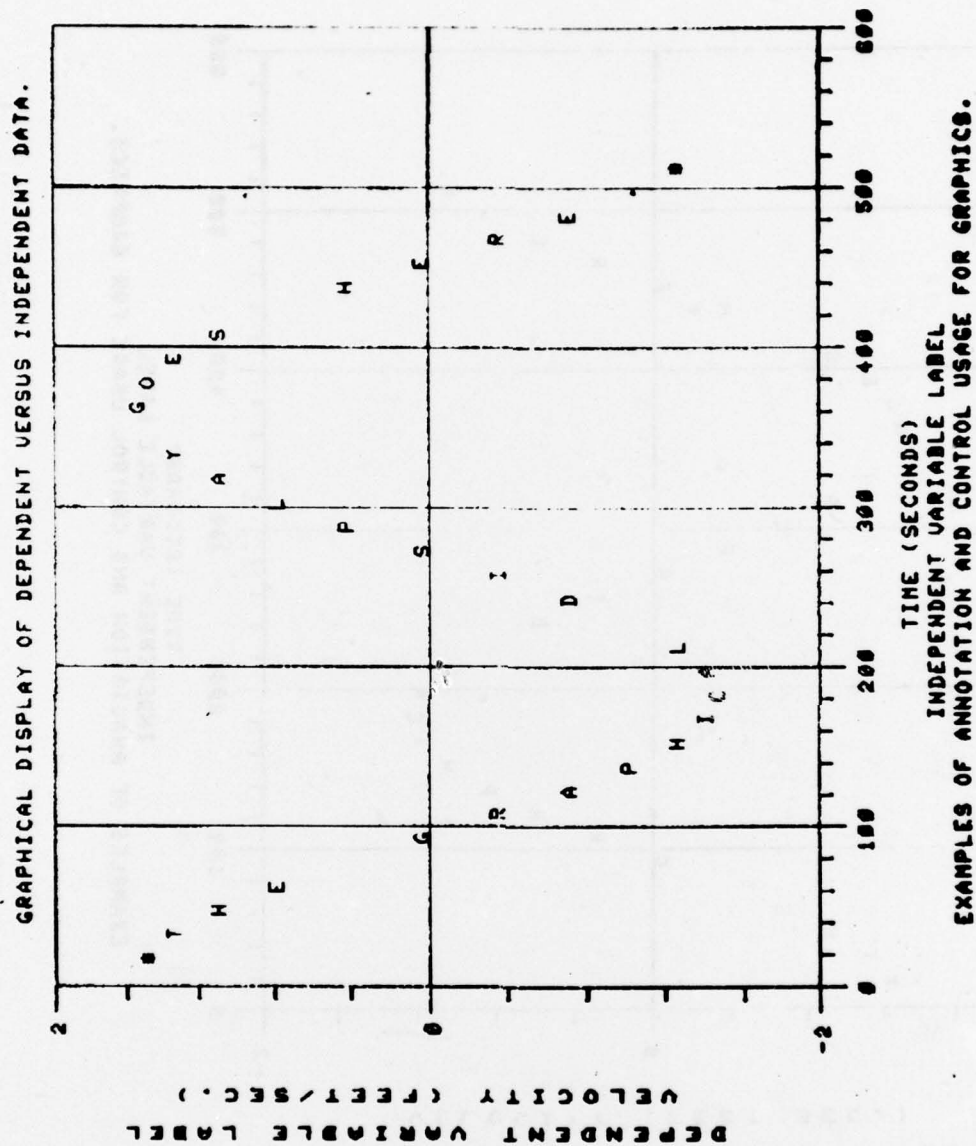


Figure C-5. CRT display output produced by program example number 3.


```

1:      SUBROUTINE DATER
2:      DIMENSION NAME(20), IDAT(22)
3:      DATA NAME / 68,82,65,87,78,32,66,89,58,32,76,46,32,83,46,32, 73,
4:      183,79,77 /
5:      DATA IDAT / 68,65,84,69,58,32,56,32,79,67,84,79,66,69,82,32,49,
6:      157,55,54,32,32 /
7:      DATA NCV, NCD / 20, 22 /
8:      C          RJTPJT NAME
9:      CALL M9VABS(1000,500)
10:     CALL ANM9DE
11:     CALL WT7611(21)
12:     DO 11 II = 1,NCV
13:     CALL WT7611(NAME(II))
14:     CALL WT7611(8)
15:     CALL WT7611(10)
16:     10 IF(NSTCK(II) .GE. 3) GO TO 10
17:     11 CONTINUE
18:     C          RJTPJT DATE
19:     CALL M9VABS(975,500)
20:     CALL ANM9DE
21:     CALL WT7611(21)
22:     DO 21 JJ = 1,NCD
23:     CALL WT7611(IDAT(JJ))
24:     CALL WT7611(8)
25:     CALL WT7611(10)
26:     20 IF(NSTCK(JJ) .GE. 3) GO TO 20
27:     21 CONTINUE
28:     CALL WT7611(21)
29:     CALL WT7611(21)
30:     CALL WT7611(21)
31:     C
32:     RETURN
33:     END

```

Figure C-7. Listing of subroutine DATER.

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DATE: 8 OCTOBER 1978

Figure C-8. CRT display output produced
by subroutine DATER.

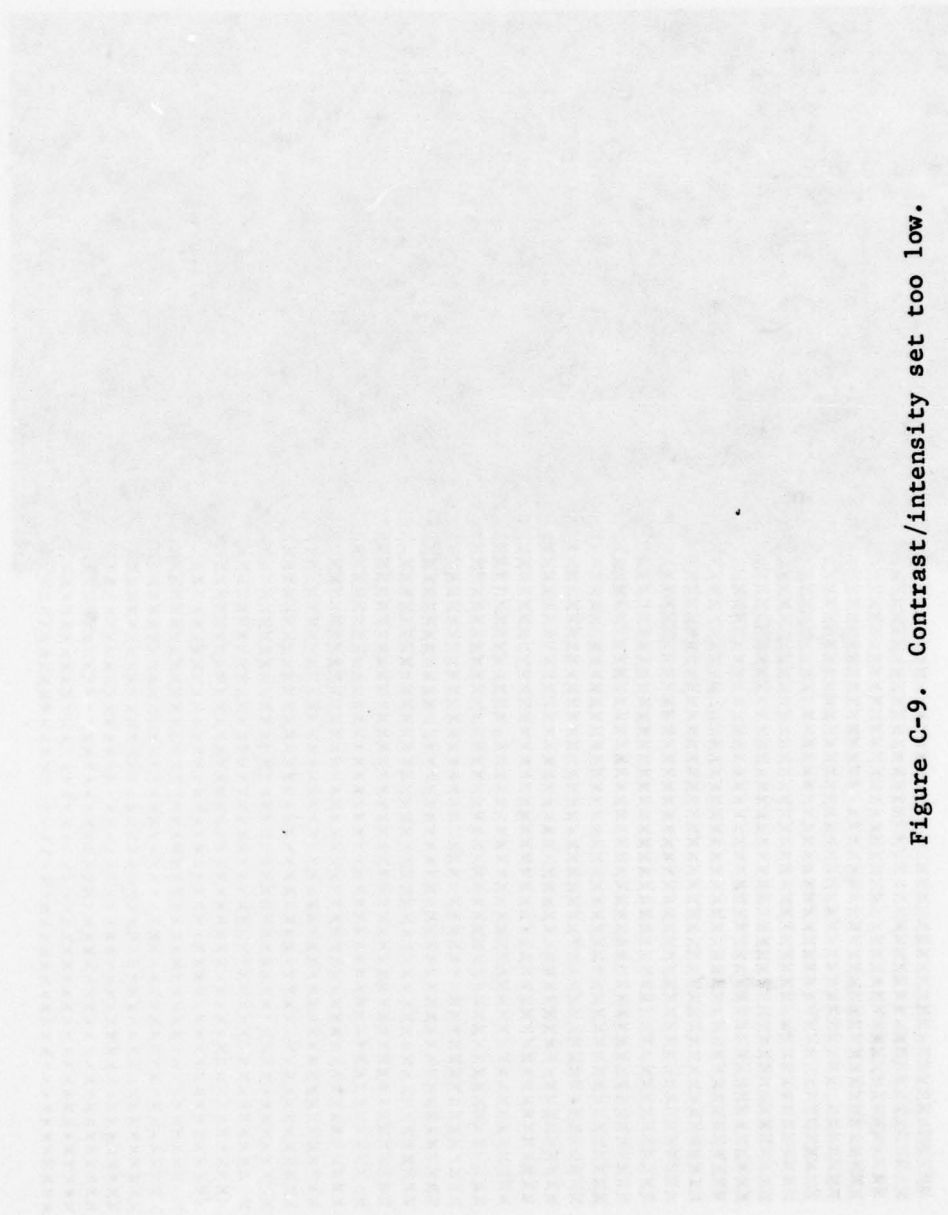


Figure C-9. Contrast/intensity set too low.

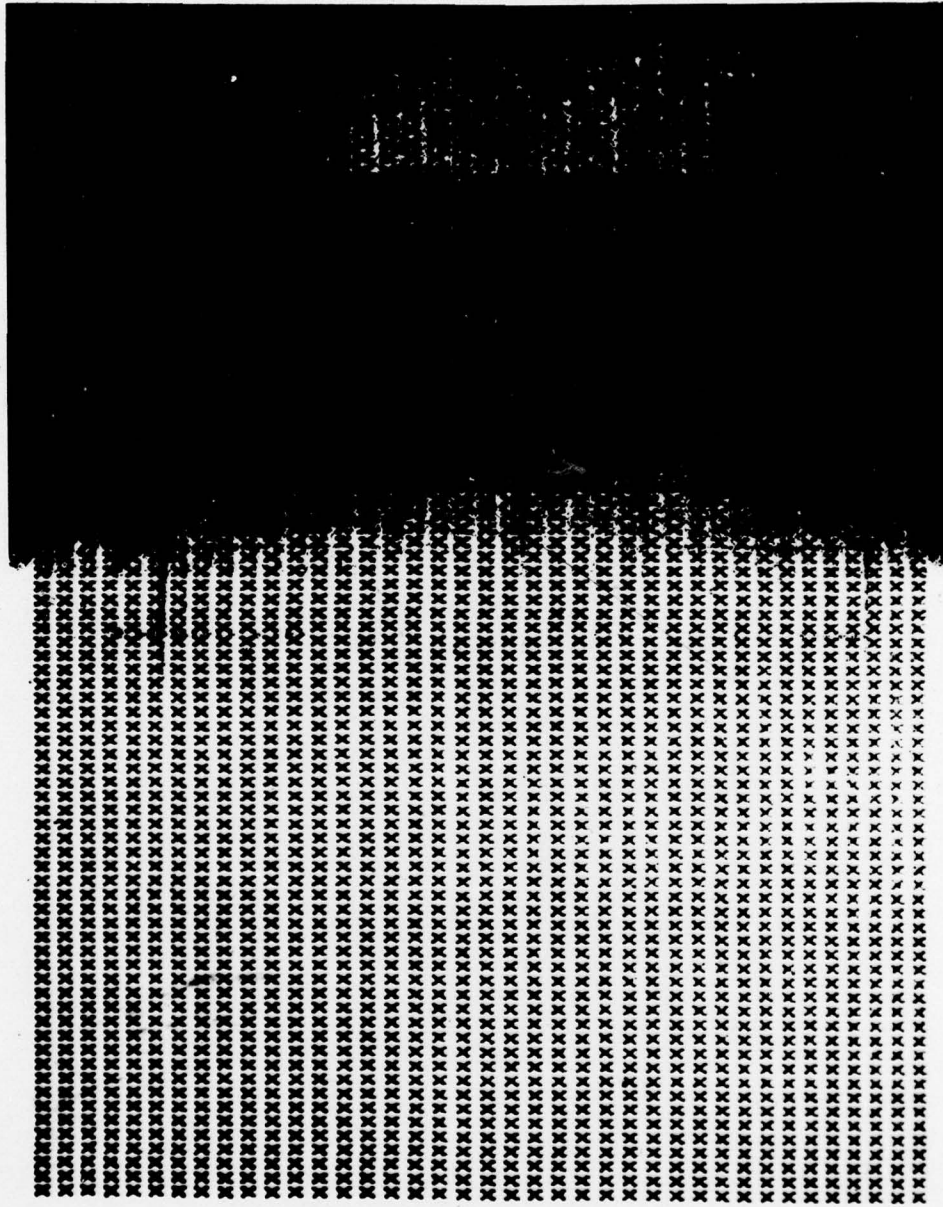


Figure C-10. Contrast/intensity set too high.

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